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The Re-presentation of Arabic Optics in Seventeenth-Century Commonwealth England

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The Re-presentation of Arabic Optics in Seventeenth-Century Commonwealth England

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The Re-presentation of Arabic Optics in Seventeenth-Century Commonwealth England

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Arabic Studies experienced a resurgence in seventeenth-century English institutions. While an awareness of the efflorescence has helped recover a fuller picture of the historical landscape, the enterprise did not foment an appreciable change in Arabic grammatical or linguistic expertise for the majority of seventeenth-century university students learning the language. As a result, the desuetude of Arabic Studies by the 1660s has been regarded as further evidence for the conclusion that the project reaped insubstantial benefits for the history of science and for the Scientific Revolution. Rather, this inquiry contends that the influence of the Arabic transmission of Greek philosophical works extended beyond Renaissance Italy to Stuart England, which not only shared a continuity with the continental reception of Latinized Arabic texts but selectively investigated some sources of original Arabic scientific ideas and methods with new rigor. The case study at hand demonstrates how one English physician in the Commonwealth period turned to a medieval Muslim author of optics to dispel reliance on either mechanical, deterministic or occult explanation of natural phenomena.

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Introduction

Historical inquiries have established that the transmission of Arabic knowledge in Europe peaked in the medieval and early modern periods before declining irrevocably at the end of the seventeenth century. The case of England, in particular, is noteworthy because interest in the study of the Arabic language surged during the reign of the Stuarts and then advanced unabated through the period of the civil wars and Interregnum. This investigation presents new evidence for the study of Arabic thought in a later period—Commonwealth England, 1649-1659. Scholarship has considered Descartes the last early modern to have read and drawn on the well-regarded Arabic monograph, *Kitāb al-Manāẓir* (*Optics*) by the Cairo-based polymath Ibn al-Haytham (Latin *Alhazen*, 965-1039), to expound a system of natural philosophy.[1] Mathematicians such as John Wallis and Christiaan Huygens, on the other hand, continued to present alternative solutions to Alhazen's Problem concerning mirror reflection through the 1670s.[2] As the current study will demonstrate, Descartes was not, in fact, the last of early modern European authors to engage with Ibn al-Haytham's *magnum opus* in their writing. The English physician Walter Charleton (1620-1707) drew on Ibn al-Haytham's arguments, proofs, and visual experiments substantially in his *Physiologia* (1654) in the period after Descartes had presented his mechanical philosophy.

Charleton was responsible for the diffusion in England of the French priest and philosopher Pierre Gassendi's atomist theory of matter. Published at Basle in 1572, the most recent edition of Ibn al-Haytham's optics was Friedrich Risner's *Opticae Thesaurus*.

[1] Charles C. Gillispie, "Ibn al-Haytham" in *Optics, Astronomy and Logic (*Aldershot, Hampshire, England: Variorum, 1994), 197.

[2] M.B. Hall, "Arabick Learning in the Correspondence of the Royal Society 1660-1677," in *The 'Arabick' Interest of the Natural Philosophers in Seventeenth-Century England* (Leiden: E. J. Brill, 1994), 153-4.

A critical edition and English translation of *Opticae Thesaurus* by A.I. Sabra now makes possible a comparative inquiry of the *Physiologia*'s models and those of Ibn al-Haytham in Latin circulation. Natural philosophy comprehended optics at the time. This paper will attempt to elaborate the reasons why English scientists continued to refer to the work of Ibn al-Haytham during the Republican period.

Historiography

The secondary literature has shown that prior to the Stuart reign the Tudors devoted considerable energy to strengthening diplomatic and commercial ties to Muslim realms, sharing continental ambitions and activities like developing Arabic linguistic skills for royal correspondence. During the same period Englishmen displayed increasing curiosity about Arabic culture. Travel narratives and performances introduced representations of Arabs and Muslims.[3] In another vein, Nabil Matar has provided an expansive view of the cultural context of appropriated Arabic thought and its philosophical underpinnings.[4] Contributing authors in G.A. Russell's edited volume on Arabic Studies in seventeenth-century England have surveyed institutional learning, speculating a causal connection to English intellectual developments.[5] Meanwhile, G.J. Toomer has evaluated the island's Arabic Studies comprehensively without claiming any influence or explaining the preponderance of philosophical, scientific or mathematical

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[3] Gerald MacLean and Nabil Matar, *Britain and the Islamic World, 1558-1713* (Oxford: Oxford University Press, 2011).

[4] Nabil Matar, *Islam in Britain, 1558-1685* (Cambridge: Cambridge University Press, 2008).

[5] G.A. Russell, editor, *The "Arabick" Interest of the Natural Philosophers in Seventeenth-Century England* (Leiden: E.J. Brill, 1994).

predilections in the enterprise.[6] The one opinion on which the secondary literature agrees is that Arabic Studies declined irrevocably by the end of the century.

The Latin Background of the *Optics*

Abū ʿAlī al-Ḥasan Ibn al-Haytham's *Kitāb al-Manāẓir* played a substantial role in developing ocular studies in Europe. Translated into Latin in twelfth-century Spain, the work spread in different versions throughout the continent and reached England as well. It was cited in disparate sources ranging from the medieval French poem *Roman de la Rose* to Latin tracts by the English natural philosopher Roger Bacon (1214-1294) and the English theologian John Wyclif (d. 1384). Studied formally at Oxford since the thirteenth century, the treatise was well known to a broad swath of the learned population.[7] In its Latin forms, *Optics* circulated as Gerard of Cremona's (d. 1187) *De aspectibus* or through largely derivative works--Bacon's *Perspectiva* (Roger Bacon, c. 1265), Witelo's (d. c. 1314) *Perspectiva* (c. 1275), and John Pecham's (d. 1292) *Perspectiva communis* (c. 1280).[8] As A. Mark Smith notes, "By the mid-fourteenth century, it had become enough of a staple to have been translated into Italian."[9] In the seventeenth century, however, the

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[6] Gerald J. Toomer, *Eastern Wisedome and Learning: The Study of Arabic in Seventeenth-Century England* (Oxford: Clarendon Press, 1996).

[7] A. Mark Smith. Introduction to *Alhacen's Theory of Visual Perception: A Critical Edition, with English Translation and Commentary, of the First Three Books of Alhacen's* De Aspectibus*, the Medieval Latin Version of Ibn al-Haytham's* Kitāb al-Manāẓir, Vol. 1 (Philadelphia: American Philosophical Society, 2001), lxxxii.

[8] Smith, xx.

[9] Smith, xx.

popularity of the *Optics* ebbed as its usefulness diminished, according to scholarly consensus. Risner's edition was read and cited by "such mathematicians as Kepler, Snell, Beeckman, Fermat, Harriot, and Descartes, all of whom except the last directly referred to Alhazen."[10]

Methodology and Sources: Tracing Social and Intellectual Circles

In England, particularly, the resurgence of interest in Arabic sources during the middle of the seventeenth century and through the Restoration period spurred a movement to collect original manuscripts and re-translate them in the hopes of correcting the errors in previous Latin editions. At Oxford, beginning in 1645, a group of scientists and mathematicians formed around William Harvey to promote his empirical methods and extend the fruits of his discovery of the circulation to other sciences.[11] The group presented lectures and solutions of scientific and mathematical problems—some of them Greek and Arabic constructions--at their regular meetings.[12] Plans to foster collaboration across the physical, exact, and natural sciences proved successful. Members conducted experiments, cooperated on small projects, and published new research as well as commentaries.

[10] Gillispie, 197.

[11] Robert G. Frank Jr., *Harvey and the Oxford Physiologists: Scientific Ideas and Social Interaction* (Berkeley: University of California Press, 1980), 23 states that this group "has most often been treated as a precursor of the Royal Society."

[12] Colin Wakefield, "Arabic Manuscripts in the Bodleian Library: The Seventeenth-Century Collections" in *The 'Arabick' Interest of the Natural Philosophers in Seventeenth-Century England* (Leiden: E. J. Brill, 1994), 131-133 describes Kenelm Digby's lectures on Arabic sciences and John Greaves's (the founder of the Oxford group) purchase of Arabic manuscripts. Toomer, 178 also explains John Greaves's knowledge of Arabic astronomy, mathematics, and rare works such al-Bīrūni's *al-Qānūn al-Masʿūdi*.

Robert G. Frank Jr. has highlighted the striking case of Westminster School graduates who, despite comprising only a small percentage of the university student population, were disproportionately well-represented in the Oxford group as well as in the major scientific achievements at the middle of the century. He attributes this primarily to the headmaster at Westminster, Richard Busby, who was distinguished by a wide-ranging interest in natural philosophy and mathematics as well as command of Latin and Greek. His students comprised a "brilliant, disciplined, and loyal generation of pupils" including Robert Hooke, Richard Lower, Henry Stubbe, John Locke, and Christopher Wren.[13] Most of the cohort went on to attend Christ Church and maintained strong affiliations over the course of their careers in science. Frank's assessment of Westminster and Busby stands to benefit from P.M. Holt's biography of the physician Henry Stubbe (1632-1676), whose major work was the first defense of Islam in the English language.[14] Holt records the strength of Arabic study at the Westminster School for boys at the time Stubbe and his cohort attended. Busby was largely responsible. He composed his own grammar book for the language, introduced the study of Arabic into the curriculum, and included it along with Greek and Hebrew in youth extemporaneous exercises during the election of scholars.[15] Busby's promotion of Arabic, according to Holt, was "both serious and sustained."[16] The Arabic background of a majority of Harvey's followers in the Oxford

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[13] Frank, 59.

[14] P. M. Holt, *A Seventeenth-Century Defender of Islam: Henry Stubbe (1632-76) and His Book* (London: Dr. Williams's Trust, 1972).

[15] Holt, 11.

[16] Holt, 11.

group has not previously informed the analysis of their scientific activity. Although members likely had minimal linguistic proficiency, a knowledge of Arab-Islamic history and culture may have facilitated the acquisition of key mathematical and scientific sources.

Scholars such as Walter Charleton, a physician by training, benefited immensely from the scientific cross-pollination. A close companion of Harvey and Kenelm Digby, Charleton received their encouragement to pursue mechanics and chemistry.[17] With his translation and commentary of Pierre Gassendi's Epicurean philosophy, the physician introduced an alternative to Cartesian mechanical philosophy for the English public. *Physiologia Epicuro-Gassendo-Charltoniana* (1654) was widely read, facilitating the brisk diffusion of Gassendian atomism on the island. Charleton was not only familiar with Ibn al-Haytham and adopted his thought in *Physiologia*, he cited his tract and referred to its author as "that grand Master of the Opticks, Alhazen" whose methods deserved "imitation."[18]

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[17] John Henry, 'Charleton, Walter (1620–1707)' in *Oxford Dictionary of National Biography* (Oxford: Oxford University Press, 2004); online edn, Sept 2010 [http://www.oxforddnb.com.ezproxy.lib.utexas.edu/view/article/5157, accessed 17 Jan 2014], Walter Charleton (1620–1707): doi:10.1093/ref:odnb/5157.

[18] Walter Charleton, *Physiologia Epicuro-Gassendo-Charltoniana, or, A Fabrick of Science Natural, Upon the Hypothesis of Atoms Founded by Epicurus* (London: Thomas Newcomb, 1654), 159.

The Critical Text: *Optics* and *Physiologia*

Aristotelian Visual Theory

The *Physiologia* reveals a strong preference for visual phenomena. There was considerable excitement about the prospect of understanding the relationship between anatomy and functional physiology. The behavior of bodily organs and fluids drew on the abundant scientific sources on the nature of vision. Previously, however, the most significant contribution attributed to Ibn al-Haytham in optics was the confirmation of the Aristotelian intromission theory of vision through the dual study of the properties of light and the anatomy of the eye.[19] Although Charleton adopted Ibn al-Haytham's demonstrative and experimental interpretation of intromission, the *Physiologia* advanced well beyond that scope. This paper will assess the extent to which the two texts shared ideas, devices, and methods as well as to what purpose each model served.

The first major subject in which Charleton broached *Optics* was the intromission doctrine. It is important to discuss the background of this *cause célèbre*. Beginning with Aristotle, visual theory supposed a visible body shed a thin layer of itself and radiated it to the eye. The failure to provide a systematic account of the process, however, invited questions in the Middle Ages about how images of large objects could enter the smaller eye and why the size of extensive yet remote bodies were understood to be greater than they appeared.[20] In the post-Aristotelian period, the mathematicians Euclid and, much

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[19] Gillispie, 190 remarks that Ibn al-Haytham's theory is recognized as "neither identical with nor directly descendant from any one of the theories known to have previously existed in antiquity or in Islam."

[20] Averroes, *Epitome of Parva Naturalia*, transl. Harry Blumberg (Cambridge, Massachusetts: The Mediaeval Academy of America, 1961), 14 states "if the forms were conveyed to the soul through media, the soul could receive these forms only in the magnitude in which the media conveyed them to it." P.78-9,

later, Ptolemy, gradually gained wide currency. They both proposed an extramission theory in which the eye emitted material substances that sensed visible objects. Ibn al-Haytham's proof, instead, sought to establish intromission on more solid ground, selectively using the mathematicians' toolkits. He argued that the space between the eye and each point on a visible object described a visual cone. As the vertex of the "imaginary cone" the eye received rectilinear light from all points of the visual object's surface--the base of the cone--so that the cone "comprises all the straight lines imagined between that point and all points on that surface."[21] By positing a point theory of light and providing a geometrical explanation for perspectivism through a visual cone, Ibn al-Haytham offered a more convincing, mathematical model of intromission than that of Aristotle while rejecting the view that a material form of an object actually entered the eye during the visual process.

Charleton based his explanation of image reception in the cornea on intromission. At the same time, he responded specifically to objections that had never been resolved by Aristotelian intromission:

> No Image can totally fill that Receptary, unless it be derived from an object of an almost *Hemispherical* ambite, or Compass; so that the rayes, tending from it to the eye, may bear the form of a Cone, whose Base is the Hemisphere, and point (somewhat retused) the superfice of the Pupil.[22]

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see note 110: "If the form of the sense-object is imprinted upon the air and reaches the eye, how will it be possible for a large form of a high mountain or tall tower to penetrate into the eye, which is small in size?"

[21]Ibn al-Haytham, *The Optics of Ibn Al-Haytham, Books I-III on Direct Vision*, vol. 1, trans. A.I. Sabra (London: The Warburg Institute, 1989), 71, (Bk. I, 6.26).

[22] Charleton, *Physiologia*, 159.

Objects of great magnitude did not *fill the receptary* or sensitive surface of the eye. Only an object of magnitude equal to the entire horizon could overwhelm the sensory area. Founded on a perspectivist understanding, the response depended on the visual cone to account for a diminishing magnitude of the visual image as it traveled to the eye.

Ibn al-Haytham had adopted the analytic device known as a visual cone, an idea which originated with Ptolemy, who explained the eye's emission of substances as a conic area, or visual flux, which increasingly widened out from the eye. When an object passed into this visual field, the flux sensed it materially, although how that information traveled back to the eye was unclear. Smith has argued, as a result, that Ibn al-Haytham's intromission theory merely reversed the visual cone, hardly a ground-breaking achievement.[23]

The intromission principle fomented further discussion in the Middle Ages, spanning many conceptual areas. Ibn al-Haytham had first problematized each supposition previously defined in the visible cone theory. "Light will be found to extend rectilinearly in a transparent body" unless "light meets another body the transparency of which is different from that of the first body through which it extended," in which case "it will not pass into it along the straight lines" but "will be refracted at the surface of the second body and not extend rectilinearly."[24] Points of light did not always travel in straight lines due to their refractive encounters. At the cornea, the light-lines transmitted from each point of a

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[23] Smith, lxxx states "all Ibn al-Haytham did in the end was to translate Ptolemy's cone of visual radiation into a mathematically equivalent cone of visible radiation. Everything else remains the same, right down to the vertex of the cone, which still serves as the reference-point for spatial perception."

[24] Ibn al-Haytham, *Optics*, vol. 1, 68, (Bk. I, 6.18).

visible object "are imagined to be refracted in the manner required by the difference in transparency between the body of the cornea and the air."[25]

Intimately related to visual perception in *Optics* was the idea of sensing motion. Ibn al-Haytham presented various scenarios that showed how observers perceived moving bodies or compared objects as they withdrew. With respect to a moving object and a stationary visible object, the eye senses a "change in position" that "either by receding farther from or drawing closer to it, or by changing sides in relation to that object" the eye "maintains the same position" and thereby "will perceive the motion of the moving object."[26]

Similarly, Charleton moves from a focus on the visual cone to wielding its explanatory power for visual effects associated with spatial distance:

> And, because a thing, when near, doth possess a greater part of the visive hemisphere, than when remote...the special image thereof also possess a greater part of the concave in the retina tunica, and so exhibit in greater dimensions; and it decreaseth...by how much the farther it is abduced from the eye.[27]

The *special image* of an object conveyed a diminished magnitude as it receded from the observer. The particular way Charleton introduced the passage emphasized the physical displacement of visible objects from near to remote locations. Both authors demonstrate an awareness of spatial perspective and applied it to the visual process as a result of the cone theory. The phenomenon of perspective, in turn, could satisfactorily answer

[25] Ibn al-Haytham, *Optics*, vol. 1, 69, (Bk. I, 6.22).

[26] Ibn al-Haytham, *Optics*, vol. 1, 193, (Bk. II, 3.179).

[27] Charleton, *Physiologia*, 159.

criticisms directed against intromission. Whereas historians of science and mathematics either credit Ibn al-Haytham with introducing an optimal form of Aristotelian intromission or dismiss the same as unremarkable, both opinions have not advanced past conceiving of the scholar as a preserver of Greek thought. Rather, this inquiry has demonstrated that he leveraged the theory in order to ask different questions, in this case, relating to motion. The cone theory was merely a starting point for Ibn al-Haytham. This is an important finding with which to analyze the work of Charleton.

Towards a Theory of Motion

It is necessary then to depart, along with Ibn al-Haytham and Charleton, from intromission into the topical areas on which they preferred to speculate. Turning to the movement of light, Ibn al-Haytham opined that it comprises a point on the surface of a visible object and radiates an imaginary straight line or a bent line upon refraction. The multiple behaviors of light show a complexity first proposed in the visual cone. The account has received surprisingly little attention as a physical study of motion in its own right, however. In Ibn al-Haytham's account the nature of light and its activity exhibited variability. What accounted for those differences? In order to understand the development, we have first to reconstruct the various theories of matter and motion circulating in the author's time.

Of Matter and Motion in the Middle Ages

A hylomorphic matter theory prevailed during most of the Middle Ages. Aristotle had specified that all matter derived from one source which consisted of air, earth, fire, and water. These elements constituted the sublunary regions, including human and other bodies and the natural world. The first forces to put primary matter into motion descended from the celestial bodies, and these powers acted through immaterial forms.[28] Since the earth sat immobile at the center of the universe, sublunar bodies similarly had no innate motion.[29] The immaterial form, a soul impressed on the body, supplied the active principle. Since the soul-mover resided throughout the life of a body, questions remained why a particular activity took place at certain times and not at others. In terms of the natural world, Aristotle accounted for change through air and fire. These two elements were responsible for moving matter by contact, which took time and changed only external, secondary properties but modified no primary, essential properties unless bodies received a new, impressed form (soul) from the celestial region. Material alterations such as these were called generation and corruption by Aristotle. They occurred immediately. The Stagirite concluded from these tenets that bodies experienced no disintegration into smaller components because more basic elements did not exist.

Theories of matter had always carried consequences for the possibility of motion. Aristotle thought void space was not viable because in that case bodies could roam without an immediate mover.[30] For him, a medium was always necessary for motion to occur. Matter was everywhere, so he could explain any object relying on air or another body to propel it by contact. Fire, air, and water supplied the dynamic force in some cases

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[28] Nancy G. Siraisi, *Avicenna in Renaissance Italy: The Canon and Medical Teaching in Italian Universities after 1500* (Princeton: Princeton University Press, 1987), 238.

[29] Siraisi, 238.

[30] A. Y. Al-Hassan, ed., *The Different Aspects of Islamic Culture*, Vol. 4*, Science and Technology in Islam Part I: The Exact and Natural Sciences* (Beirut: UNESCO Publishing, 2001), 321.

yet fire and air were defined essentially by lightness, a contradiction that would later unravel his doctrine. In any case, the Stagirite claimed that motion was an essential property of air and of the soul, not of bodies. The explanation was unsatisfactory for projectiles, and it related to the problem of the soul-mover. Why did an object continue moving after it was thrown, when contact with the mover was severed? Why did particular behaviors occur at certain times when the soul-mover did not change? An active internal principle could have explained the phenomena, but Aristotle refuted those who held similar opinions.

An alternative matter theory, corpuscularian philosophy, challenged Aristotelian physics. This school accepted free space and small discrete particles in the substructure. Earlier conceptions from the pre-Socratic Democritus and post-Aristotelian Epicurus proposed that the basic components of matter are indestructible atoms. These notions explained change in the world without relying on immaterial forms. The Stagirite, however, failed to justify projectiles, and his dynamics theory finally met its demise as a result in the sixteenth and seventeenth centuries.[31] In the meantime, corpuscularian and atomist philosophies surfaced intermittently in the medieval Near East and Latin West. The hybridization of the two theories, in the midst of occult thought, apparently created problems, as we will see shortly.

A Christian author in Alexandria had responded to Aristotelian physics by arguing for projectile motion. John Philoponus (fl. c. 530 CE), a theologian and philosopher,

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[31] Al-Hassan, 321.

conceded theoretically that a space not completely filled with matter was tenable.[32] He described an incorporeal dynamic force which propelled an object without resorting to force imparted from the air or any other body. To explain how motion continued after an object was hurled, John described a natural internal inclination, an "impetus," which carried on the movement.[33] The principle made a medium unnecessary for movement, an important correction. Further, an understanding of motion as an internal and undetermined active property--which took time--in bodies, was a dramatic modification. Whereas John did not explicate the motion of corpuscles or suggest an alternative matter theory, he seemed to approach the subject in his discussion of light. Establishing several proofs regarding light and motion at a particulate level, John nearly reversed the allowances he had made for impetus.

> 1) Since light does not move in time it is not a body
> 2) If light were a body in air, it would be a body interpenetrating a body which implies the cosmos could fit into a mote
> 3) Light would make illuminated air more dense if it were a body
> 4) As the opposite of darkness, which is not a body, light cannot be a body.[34]

Aristotle had supposed that time was the measure of motion as well. Because light moved too quickly for the eye to perceive it, its motion appeared dissimilar to the movement of a body. Even for John, who theoretically accepted free space and exhibited interest in the

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[32] Marshall Clagett, *The Science of Mechanics in the Middle Ages* (London: Oxford University Press, 1959), 433.

[33] Al-Hassan, 325.

[34] Peter Adamson, "Vision, Light, and Color in al-Kindi, Ptolemy and the Ancient Commentators" in *Islamic Medical and Scientific Tradition: Critical Concepts in Islamic Studies*, vol. 4, edited by Peter E. Pormann (London and New York: Routledge, 2011), 25.

nature of light, its observed behavior failed to provoke a revision of motion or matter theory.

As the primary reconciliation of Greek metaphysics/physics and Christian ontology, John's work diffused widely and rapidly in Muslim lands during the Abbasid caliphate. With its capital in Baghdad, the court actively sought Greek works of medicine, mathematics and philosophy from Egypt and Syria. Ḥunain ibn Isḥāq (d. 873), the scientist and translator, had rendered John's *Physics*, *De anima,* and *De Generatione et Corruptione* into Arabic during the time the philosopher al-Kindī served alongside him at court. The Muslim philosopher and physician Avicenna (980-1037) later read these Arabic versions. Despite the fact he primarily disagreed with John in metaphysics, he borrowed the latter's impetus principle.[35] Still, he criticized John's commentary, which agreed with a group of ancients (*qawm qudamāʾ*), in assuming one and many, or unity and multiplicity, are contraries.[36] Rather than one impetus (Arabic *mayl*) for a body as in John's account, Avicenna described three: a natural internal motion (*mayl ṭābīʿī*), an applied force (*mayl qasrī*), and an impressed form (*mayl nafsānī*) for bodily organs.[37] Still, only one kind of *mayl* could obtain in a body at a given time. Defined as a natural lightness or heaviness by Avicenna, natural impetus was folded in to the *Physics*. According to Amos Bertolacci, these and other modifications marked "the last and widest of a series of transformations of Aristotle's *Metaphysics* that took place during the Middle

[35] Amos Bertolacci, *The Reception of Aristotle's Metaphysics in Avicenna's Kitāb al-Šifā: A Milestone of Western Metaphysical Thought* (Leiden: Brill, 2006), 452.

[36] Bertolacci, 336.

[37] Al-Hassan, 328-330.

Ages" as they were not commentaries but "original reworkings" which "anticipate the Modern approach to metaphysics."[38] In the eleventh century, a reception of Avicenna included this adaption, to which Ibn al-Haytham was privy. Much later, Charleton, too, understood the significance of a natural internal motion and adopted it in *Physiologia*. At this point we can return to a comparative analysis of the two texts.

Perceiving the Physical World

Ibn al-Haytham relied on the visual cone to discuss perception in terms of size and distance. He began with the example of a body difficult to discern in the following passage.

> Thus if the object is extremely small, the cone that is between it and the eye's centre will be extremely narrow and therefore the part which it cuts off from the surface of the sentient [organ] will be extremely small, being like a point of no magnitude. Now the sentient [organ] senses the form in its surface only if the part of its surface in which the form occurs has an appreciable magnitude in relation to the whole [of this surface].[39]

The cone is originally used to define the geometrical spatial distance which a gradually diminishing image must travel to reach the eye as points of light. The concern here has shifted to the size of a visible object, whether far and apparently small or near and actually diminutive. In either case, visual receptivity includes a recognition of a lower limit, *an appreciable magnitude,* of the eye's surface area. Speaking of the eye's sensitive capacity, Ibn al-Haytham noted that "the powers of the senses are limited."[40] The supposition

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[38] Bertolacci, viii.

[39] Ibn al-Haytham, *Optics*, vol. 1, 107, (Bk. I, 8.7).

[40] Ibn al-Haytham, *Optics*, vol. 1, 107, (Bk. I, 8.7).

became a formal part of his visual theory, one of eight conditions for an object's perceptibility.

Charleton constructed a hierarchy which elaborated his own conditions for sight, below.

> ***First***, that as well philosophers, as oculists unanimously admit three ***degrees***, or gradual differences of sight. (1) ***Visus Perfectissimus,*** when we see the smallest (visible) particles of an object, most distinctly: (2) ***Perfectus***, when we see an object distinctly enough, in the whole or parts, but apprehend not the particles, or *minima visibilia* thereof: (3) ***Imperfectus***, when besides the object directly obverted to the pupil of the eye, we also have a glimmering and imperfect perception of other things placed ***ad latera***, on the right and left side of it.[41]

Charleton gives lateral sight the lowest order, characterized by the haziness and inexactitude of peripheral vision. Proceeding higher, perfect vision brings us aggregated data but not necessarily visual acuity. Truly perfect sight has access to the *minima visibilia* (smallest particles) available to the senses. By identifying this capability as very perfect vision Charleton shows greater confidence in minimal perception than Ibn al-Haytham.

During the period the physician wrote *Physiologia*, a historical dispute over ocular theory threatened to resurface. The issue involved the reception of light in the eye through the pupil's dark tissue. Did it facilitate visual accuracy or occlude reality? Charleton addressed the ongoing debate which "hath made the schools both of anatomists and professors of the optiques, ring again with controversies."[42] Medical authors had disagreed about the purpose of the pupil, the tiny dark opening located at the center of the iris which

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[41] Charleton, *Physiologia*, 167.

[42] Charleton, *Physiologia*, 174.

received light and then directed it to the retina. Charleton asks "to what end Nature provided this opacating Tincture."[43] He cites Ibn al-Haytham's response first and quickly discounts it. "According to the position of ***Alhazen …***as a small light in a dark obscure place is better perceptible, as diffusing a brighter lustre, than in a wide, luminous place...the rayes deradiating from it by reflection from the opposite opacity of the Membrane, becoming reassembled and united in a more vigorous lustre."[44] After rejecting other opinions, he concludes with his own view that "the only and proper use of this...sooty blackness is, that the rayes of light, incident on the concave...and thence resilient back to the concave of the uvea tunica, might by the blackness of its lining be extinguisht, i.e. absolutely terminated: lest thence again reflected...they might perturb the visible image, and consequently the sight."[45] The argument is a significant one, introduced by the comment that the schools "ring again with controversies" so that Charleton thought he could resolve the long-standing issue. As we will see, he depended on Ibn al-Haytham's treatment of the problem though he seemed to dismiss it. That he referred to him at all is suggestive.

Ibn al-Haytham actually had deliberated on the same issue. A distinction between opacity and transparency permitted him to differentiate the reception of light in any body, including the eye. Regarding the pupil specifically, he asserted first, "It is black in order to darken the albugineous and crystalline humours so that, because of this darkness, the

[43] Charleton, *Physiologia*, 174.

[44] Charleton, *Physiologia*, 174.

[45] Charleton, *Physiologia*, 175.

forms of weak and inapparent lights may appear in them."[46] Further, he elaborated that the pupil is not only black but "thick and somewhat firm."[47] There are reasons for the vivid additional properties: "The thickness [of this coat] further darkens its interior. If it were thin the white of the conjunctiva would show through from behind it, but its thickness intensifies the darkness inside it."[48] An accurate identification of opacity resorted to density--a tough, thick, and dark membrane. Charleton claimed opaque objects *extinguisht* light as if it were a flame whereas Ibn al-Haytham believed opacity mediated the *amount* of light coming in to the smallest degree necessary for perception (*forms of weak and inapparent lights*). Completely obliterating light was not understood in the latter work as the functional reason for the pupil.

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[46] Ibn al-Haytham, *Optics*, vol. 1, 100-1, (Bk. I, 7.4).

[47] Ibn al-Haytham, *Optics*, vol. 1, 100, (Bk. I, 7.4).

[48] Ibn al-Haytham, *Optics*, vol. 1, 101, (Bk. I, 7.4).

A Significant Revision to Matter Theory

At this point a summary of Ibn al-Haytham's model of the behavior of light is helpful. The main tenets of the theory are: 1. Points of light propagate rectilinearly; 2. They slow in denser media. 3. Due to their minimal, imperceptible size, it has not been assumed that they are able to penetrate other bodies. 4. Light moved through transparent bodies and was not itself moved, needing no medium to propagate it as Aristotle had envisioned. Thus, we can conclude that Ibn al-Haytham's theory allowed for indivisible units or points of light to move as a natural substructural activity that nonetheless predicated order. By reasoning, the unobserved could be analogized to observed phenomena. Ibn al-Haytham used prolixity as a repetitive confirmation of perceived phenomenon to reiterate that the behavior of light at a minute level seemed to approximate a law of nature. For Charleton this meant that light as an observable phenomenon could explain how other bodies moved and of what they were composed. The basic quanta of the natural world thereby could be said to exhibit multiplicity in motion even while being constrained by rational principles.

An appeal to minute particles navigating vast free space provided a stable foundation for a new matter theory. It avoided the determinism in Democritus's theory in which atoms behaved mechanically. Greek atomism held that physical properties obtain at the particulate level, so that air atoms exhibit airiness, whirling, and lightness while water atoms were slippery—basically Aristotelian positions imposed on small-matter. Ibn al-Haytham's model avoided the utter randomness of Epicurean philosophy as well, which held that atoms moved spontaneously and without constraint.

Although Ibn al-Haytham did not introduce atomism, his conceptual use of imaginary points of light with natural and internal powers of motion approximated certain of Ibn Sina's notions. For Charleton these principles were tasked with addressing many long-standing controversies.

A recourse to principles of natural particulate motion made Charleton a target for accusations of atheism. As far as he was concerned, he had demonstrated that a designer had created small-matter with "innate and co-essential mobility."[49] God had not created primary matter, regarded as the four elements designated by Aristotle, but had, rather, created atoms with natural powers of activity first. The origination resulted in particles ready for self-motion. From there the natural world operated on a uniform set of principles but also with contingency as atoms aggregated, separated or dissolved through naturally-possessed internal capacities and external forces. In this way, the cosmos, once set in motion, resorted to its own propensity for movement without metaphysical or supernatural intervention. This *natural* inclination resided in the basic components of the natural world, the atomic make-up of matter.

Transmission of Experimental Proofs

We can look at one final instance of a shared legacy in the two authors' reliance on experimental trials of visual phenomena. In each case the proof held consequences for the underlying theory of matter. First, we will look at Charleton. He introduces the trial under the heading "*That many, nay myriads of different species may be coexistent in the common medium, the aer; and yet no necessity of the coexistence of many bodies*

[49] Charleton, *Physiologia*, 269.

in one and the same place."[50] He presents the trial as a commonplace event but deduces proofs from it as if it were an experiment:

> Have you not frequently observed, when many candles were burning together in the same room, how, according to the various interposition of opace bodies, various degrees of shadows and light have been diffused into the several quarters of the same? and can you give any better reason of those various intersections and decussations of the several lights, then this; that the rayes of light streaming from the diverse flames, are directly and inconfusedly trajected through the several inane receptaries of the aer, respective to the position of each candle, without reciprocal impediment.[51]

He insists that, at the particulate level, points of light that move side by side do not impede one another's activity or interpenetrate the basic unit. The account is almost identical to one of Ibn al-Haytham's experiments. Ibn al-Haytham's version and proof are reproduced below:

> The proof that lights and colours do not blend in the air or in transparent bodies is [the following]. Let several lamps be positioned at various points in the same area, all being opposite a single aperture leading to a dark place; opposite the aperture let there be a wall in that dark place or let an opaque body be held facing the aperture: the lights of those lamps will appear separately on that wall or body and in the same number as the lamps, each light being opposite one of the lamps on the straight line passing through the aperture.[52]

Immediately following, he suggests the reader repeat the exercise for himself: "Now this fact may be easily examined experimentally at any time [in the following way]."[53] Ibn al-Haytham posits that several lamps, placed in the same room, do not disturb the various shadows or light trajectories but maintain their *separate* radiated points. The setting,

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[50] Charleton, *Physiologia*, 156.

[51] Charleton, *Physiologia*, 156.

[52] Ibn al-Haytham, *Optics*, vol. 1, 90, (Bk. I, 6.85).

[53] Ibn al-Haytham, *Optics*, vol. 1, 90, (Bk. I, 6.86).

observations, and arguments of the procedure are nearly duplicated by Charleton. Without a non-occult theory of matter, this conception would not be possible. Although we know this is the case because Charleton was writing to confirm Gassendi's philosophy, this has not been acknowledged for Ibn al-Haytham. The latter asserted that, at the substructure, points of light passed through the interstitial spaces of other bodies. The permeation caused no alteration to the transparent body or loss of motive force because the quanta of light were *indivisible* units which could not be further separated or interpenetrated. Radiated light continued in direct lines, able to *pass through* other bodies but *not blend*, intersecting with various other light emissions.

Notably, Charleton expressed the same concern as Ibn al-Haytham that particulate matter does not *impede* or subvert other transparent bodies. The occult tendencies in this line of thought are notable. That Ibn al-Haytham and Charleton appear to address the same problem is also compelling in its own right. Whereas some opinions have claimed the visual cone theory is unremarkable and others have praised it as a signal of Ibn al-Haytham's Aristotelianism, the view fails to take seriously the ubiquitous nature of occult ideas and beliefs that premodern philosophical and scientific interventions addressed, as Keith Thomas has made clear.[54]

The decision to reverse extramission theory was a grave task, analogous to overturning occult doctrine. That Ibn al-Haytham accomplished it subtly and without referring to historical authors polemically, does not warrant dismissing the audacity and

[54] Keith Thomas, *Religion and the Decline of Magic: Studies in Popular Beliefs in Sixteenth and Seventeenth Century England* (New York: Scribner, 1971).

significance of his model. Many of these pre-modern issues were still alive, obviously, for Charleton and his circle. Certainly, Ibn al-Haytham accomplished much more than a confirmation of intromission, as this paper has attempted to show with respect to perception and atomism. Future research will be needed to re-assess his *magnum opus*, *Optics*, in light of this problematic historiography.

The conundrums faced in pre-modern natural philosophy elucidate the strong continuity between Near Eastern and European contexts, and this was not due to the mere preservation of Greek knowledge. The correctives and additions to ancient learning were original, and their sophistication for the first time became translatable in the seventeenth century, the point at which historical scholarship has thought that Arabic studies was in decline. Although both Ibn al-Haytham and Charleton first established ocular theory on a reworked, empirically sound intromission, these texts record an anxiety over misreading. Charleton attempted to purify atomist philosophy from the charge of atheism while prominent mechanists such as Gassendi still endorsed the view that voids existed in which spirits could navigate the spaces between matter. The empirical turn, even as it responded to these considerations, marked the beginning of the end for the long-spanning connection between Arabic and European sciences and philosophy.

Charleton on the Epicurean Philosophy

In 1652 before he wrote *Physiologia* Charleton had attacked the "vanity of Epicurus" in *The Darknes[sic] of Atheism Dispelled*.[55] The title page stated the treatise was "to be sold at the signe of the Great Turks Head over against Fetter-Lane in

[55] Walter Charleton, *The Darknes of Atheism Dispelled by the Light of Nature* (London, 1652), 116.

Fleetstreet.” The author’s opinion of Epicurus’s principle of impetus for atoms is reproduced here.

> There is yet a fourth incongruity in this doctrine of Epicurus, worthy our explosion...That Atoms had, from all eternity, a faculty of Motion, or impetuous tendency, inherent in them, and received not the same from any forreign principle, or impression extradvenient. But yet can I meet with no impediment, that may hinder me from conceiving, that Atoms are perpetually active and moveable, by the agitation of that internal tendency, or virtual impression, which the Father of Nature conferred upon them, in the first moment of their miraculous production *ex nihilo*.[56]

According to the physician, Epicurus had equated “the condition of a blissful and immortal Nature” with the “character of Divinity.”[57] Charleton blamed “the impiety” of the Greek thinker and his followers for misleading others into disbelieving in “Universal Providence.”[58] The apparent effect, a “curtain of objections”, obscured the truth from “less ocular discerners” and “terminated the vision of those whose opticks have not been strong enough to transfix it.”[59] He suggested that “*Gassendus* had very good reason to justifie *Epicurus*” when the French philosopher accepted the Epicurean equivalence between “Fortune and Nature.”[60] Still, Charleton asked, “Yet cannot a profound and more ocular scrutiny be terminated therein: for the *example* introduced to explain it, comes largely short of a requisite *adaequation*.”[61] The passage referred to an anecdote of

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56 Charleton, *Atheism*, 46.

57 Charleton, *Atheism*, 116.

58 Charleton, *Atheism*, 116.

59 Charleton, *Atheism*, 116.

60 Charleton, *Atheism*, 293.

61 Charleton, *Atheism*, 293.

a man who struck it rich by finding buried treasure. The discovery, according to Charleton, was explained by a "concourse" of many causes rather than just "occultation" or the clandestine workings of Nature/Fortune.[62]

> Thus if any man, who foreknowes, or at least conjectures, that such a Person will come and digg in such a place, doth there hide treasure, to the end that the other may find it: in this case, in respect to him that hid it, the Invention of the treasure is not a Fortuitous Effect; but in respect to him, who unexpectedly finds it, it is.[63]

His scepticism reaches to the mythical past, the "Astrologers praediction" of "the fall of an house" (Aeschylus), about which Charleton charges, "nor could he possibly foresee that prodigious mischance impendent."[64]

Charleton reflected instead on William Harvey's experiments. "We have it from the pen of that oraculous Secretary of Nature, Dr. *Harvey*, that he never dissected any Animal, but he always discovered something or other more than he expected."[65] The following statement summarized Charleton's position on natural scientific discovery.

> Perhaps some of our Readers may here have occasion to say as much of this our Dissection of *Fortune;* for while we have exercised our thoughts in the exploration of her Nature, we have unexpectedly found that, if considered *per se & reverà,* she hath no nature at all, i. e. that *in Reality she is nothing.* For, when we have abstracted all those Causes in the Concurse, which act *per se,* or by natural virtue; there remains no more but a meer *Privation* or *Negation* of all Praenotion in the concurrent Causes

[62] Charleton, *Atheism*, 293.

[63] Charleton, *Atheism*, 293.

[64] Charleton, *Atheism*, 294.

[65] Charleton, *Atheism*, 295.

> of that particular Concurse, and also of the intention and expectation of the subsequent Event.[66]

In the end, *ocular scrutiny* of the physical world yielded no great knowledge of causation. A *dissection of Fortune*, instead, resulted in a poverty of *meer privation or negation* where merely a teleology of *intention and expectation* could be pursued. Close attention to the quanta of nature through dissection and visual demonstration represented the true keys to discovery. Under such a program, scientific inquiry broke away from judicial astrology. Ocular concern for investigation at the particulate level provided a visual scrutiny which in this account replaces occult interest in hidden causes and astrological manipulation of future events.

Charleton modeled his physiology on Ibn al-Haytham's point theory to overcome Epicurean randomness, Gassendi's lack of empiricism, and lingering occult beliefs. There was a continuity between Arabic and European intellectual concerns so that learned men in each milieu shared philosophical problems as well as the attempts to resolve them. Charleton's remarkable synthesis shows that he was able to capitalize on the resurgence of Arabic studies in seventeenth-century England whereas other authors had not excavated Risner's edition of Ibn al-Haytham so fully. Further study of the depth of Arabic studies in England are needed in order to gauge how the Oxford group and other philosophical clubs may have tapped a collective knowledge when it came to studying these Arabic scientific manuscripts.

[66] Charleton, *Atheism*, 295.

The Impact of *Physiologia*

Although Gassendi and Descartes agreed that corpuscles constituted the small stuff of matter, there was no consensus on the question of their movement. Descartes thought only contact enabled motion so that a void with free-moving atoms was impossible. His contemporary believed that a vast amount of space surrounding small, indivisible particles was not only conceivable but demonstrable through argumentation. With *Animadversiones* and its companion piece *Syntagma* Gassendi prepared anti-Aristotelian natural philosophers to accept an atom-based physics that replaced Cartesian mechanics. The only thing missing was an experimental proof. Robert Boyle and other scientists made important contributions with chemical and mechanical lab trials in that regard. Prior to those milestones it was Charleton whose learned medical background helped him introduce in England an atomism informed by ocular physiology.

If the acceptability of new scientific doctrine depended on empirical verification, Gassendi's proposal had fallen short. It remained unconvincing because the philosopher had, in fact, aspired to an empirical framework but failed, on just those terms, to present documented experimental trials which confirmed his theory. Further, many of his suppositions contradicted empirical principles. In *Syntagma* he assigned a weight essential to atoms, but that was incompatible with mechanical causation. The French philosopher had turned to Epicurean atomism as an alternative to Aristotle's plenum-based natural science. Epicurus, however, had not based his theory on an experimental program demonstrating free movement. The Greek thinker had not specified essential weight at the particulate level, either. As a result, the conundrum faced by Gassendi occurred not in spite of the Epicurean philosophy but directly as a result of it.

In large part, the *Physiologia* responded to the questions that the *Syntagma* had provoked. Charleton related his experiences in the lab and the trials which could validate atomist theory. Many of his examples, discussed above, involved the two fields of optics, the anatomy of the eye and the nature of light, brought together in Ibn al-Haytham's *Optics*, the first work to reformulate the discipline by combining them. The *Physiologia* directly cited Ibn al-Haytham, referring readers to his work, but not all material borrowed from the Muslim author was recorded. This may have been an omission on the part of Charleton or perceived as unnecessary since he indicated Ibn al-Haytham clearly as an authoritative source, *the master of Optics*. The similarity of Charleton's arguments, trials and proofs with Ibn al-Haytham's experiments and ideas are too great to be regarded as coincidences or arising out of other sources, given the direct and laudatory reference. Charleton's essay emphasized the particular relevance of experiments focused on the physiology of the eye and on the behavior of light. In addition, the explication of motion in terms of visual reflection and refraction was not fundamentally mechanical. The account betrayed Ibn al-Haytham's explanations of optical, non-mechanical motion emerging through an experimentally-verified knowledge base. These were the aspects of Ibn al-Haytham's work that the *Physiologia* melded while disseminating Gassendi's ideas in another country and through another language, offering an empirical validation entirely missing in the original.

Charleton's project has a direct bearing on the thesis by Nancy Siraisi that medieval Italian medical schools re-interpreted traditional Arabic medicine such as Avicenna's *Canon* by supplementing it with contemporary theories and empirical research in cosmology and natural science, thereby updating the text and commentaries to the status of Renaissance medical treatises. In an attempt to learn what circumstances could have caused the prolonged use of conventional Arabic medicine, the usefulness of Ibn al-Haytham's models in seventeenth-century physiology is suggestive. Further exploration is necessary to gauge the extent that permutations of Arabic natural science lived along the Aristotelian variety at the medical school in Padua.

Turning to Epicurus

Possibly, the most challenging reconciliation in seventeenth-century English thought is the Epicurean turn. The Greek philosopher proposed spontaneous movement in free space, contradicting the one tenet Hobbes made a central feature of his physics—motion by contact. Richard Tuck has claimed that post-sceptical philosophy "leads rather naturally to atomism, as Epicurus found" although William R. Newman has objected to the claim that Greek atomism derived from an experimental program.[67] In a period of increasing epistemological doubt, the Epicurean tradition revived by Gassendi could not provide a new empirical framework. Arguably, Gassendi needed Charleton's *Physiologia* for that purpose. For atomism to meet the standards of scientific inquiry, a new theory of motion was required. Atoms had space to move, but their behavior conformed with natural laws. That order implied that the intellect had recourse to reason in understanding phenomena even in the minimal interstices of void space.

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[67] Richard Tuck, "Optics and Sceptics: The Philosophical Foundations of Hobbes's Political Thought," in *Conscience and Casuistry in Early Modern Europe*, edited by Edmund Leites (Cambridge: Cambridge University Press, 1988), 245. William R. Newman, *Atoms and Alchemy: Chymistry and the Experimental Origins of the Scientific Revolution* (Chicago: University of Chicago Press, 2006), 24 states that the "atomism of classical antiquity, for all its brilliance, had not originated out of an experimental context."

Reasons for the Elision of non-occult Arabic Science

Charleton had justified his exposition on the title page similarly as "the hypothesis of atoms founded by Epicurus repaired [by] Petrus Gassendus ; augmented [by] Walter Charleton." A majority of the physician's augmentation was, by his own admitting, from "the master" Ibn al-Haytham's system of physics yet he remained faithful to Gassendi's label of Epicurean atomism. Greek philosophy did not develop an experimental program nor attribute rational principles for motion at a particulate level without resorting to hooks or mechanics. Yet European scholars interested in atomism, without fail, connected their theories with the Greek thinkers Epicurus or Democritus.

The phenomenon of eliding Arabic authors during the medieval period has been considered by W. Montgomery Watt, who concluded that the "purely negative act of turning away from Islam, especially when so much was being learnt from Arab science and philosophy, would have been difficult, if not impossible, without a positive complement."[68] Europeans availed themselves of an alternative cultural tradition, the classical Greco-Roman past. During the Renaissance, the previous encouragements to pursue Arabic learning changed to attitudes described by Watt as approaching "revulsion."[69]

Nabil Matar has revised our knowledge of early modern Britain's particular encounter with the Islamic world, which at the time possessed the formidable strength of the Ottoman Empire, including North African satellites which militarily, politically and

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[68] W. Montgomery Watt, *The Influence of Islam on Medieval Europe* (Edinburgh: Edinburgh University Press, 1972), 79.

[69] Watt, 80.

economically dominated Christendom and England. Alliances with the Ottomans, intellectual and cultural engagement with Arab-Islamic legacies, and a disdain for colonizing Islamic territory distinguished England from continental Europe. Intellectual engagement primarily concerns philosophical, esoteric, and mystical knowledge, however, and non-occult sciences are not covered in any depth except to state that Arabic learning declined in the face of Newtonian physics. The prevalent reading of Arabic sciences in England as an occult enterprise figures here, supporting a paradigm of decline. More problematic is the elision of the long, shared past between Europe and Islam delineated by Watt, a continuity more difficult to appreciate in seventeenth-century England than on the continent, in terms of intellectual history. The result is an account which makes England's engagement with Islam, or Arabic sciences, for that matter, appear new and foreign, rather than lengthy, familiar, and yet no less complicated for its transformations in the seventeenth century.

Conclusion

Certainly, by the early modern period many earlier predilections cited by Watt may have re-emerged to encourage a subdued study of Arabic sciences and philosophy clothed in Greek garb. Early modern warfare had altered the landscape, so that England basked in its triumph over the Spanish Armada. Whereas no military conflict with Greece loomed on the horizon, the Ottoman Empire remained a real threat, and any political or military engagement with Muslim rulers implicated the religion. Arabic sciences, too, could never be completely detached from Islam in England. As a result, a turn away from Islam, in the Middle Ages or in the seventeenth century, signified less a simple rejection of knowledge than a negotiation of ideas adopted and attributed. The only difference is that English scientific and mathematical prowess reached new heights in the latter period, making the particularly sophisticated products of Muslim intellectual history accessible for the first time. Specifically because Arabic sciences were actively sought on the island yet retained a blemish from their association with Islam, a direct admiration of Arabic cultural achievements in philosophy and science remained an untenable opinion for the majority of contemporary authors.

As a result of the tumult of the civil wars, lax censorship laws had permitted an influx of philosophical and scientific writing. Much of the literature promulgated skepticism about the validity of any knowledge derived through human perception, dogging natural philosophical inquiries. Skeptical attitudes frequently approximated or precipitated atheism. Without some basis for confidence in the physical world and in human perception of phenomena, scientific explanatory models would have been difficult to promulgate. If scepticism was considered above all a method, it slowly acknowledged a rift between observer and observed. Rather than a complete retreat from further exploration, the method encouraged a continuity in the process of inquiry, subverting the demand for truth-content. A consciousness of the limits of scientific investigation arose as a result and encouraged sustained inquiry rather than cessation. In those spaces where perception did not avail, reason stood ready to take the place of experience while drawing heavily on it.

Works Cited

Adamson, Peter. “Vision, Light, and Color in Al-Kindi, Ptolemy and the Ancient Commentators.” In *Islamic Medical and Scientific Tradition: Critical Concepts in Islamic Studies*. Vol. 4. Edited by Peter E. Pormann. London and New York: Routledge, 2011.

Al-Hassan, Ahmad Y, ed. *The Different Aspects of Islamic Culture*, Vol. 4, *Science and Technology in Islam Part I: The Exact and Natural Sciences*. Beirut: UNESCO Publishing, 2001.

Averroes. *Epitome of Parva Naturalia*. Translated by Harry Blumberg. Cambridge, MA: The Mediaeval Academy of America, 1961.

Bertolacci, Amos. *The Reception of Aristotle’s Metaphysics in Avicenna’s Kitab Al-Sifa: A Milestone of Western Metaphysical Thought*. Leiden: Brill, 2006.

Charleton, Walter. *Physiologia Epicuro-Gassendo-Charltoniana, or, A Fabrick of Science Natural, upon the Hypothesis of Atoms Founded by Epicurus*. London, 1654.

---. *The Darknes of Atheism*. London, 1652.

Clagett, Marshall. *The Science of Mechanics in the Middle Ages*. London: Oxford University Press, 1959.

Frank, Robert G. Jr. *Harvey and the Oxford Physiologists: Scientific Ideas and Social Interaction*. Berkeley: University of California Press, 1980.

Gillispie, Charles C. “Ibn Al-Haytham.” In *Optics, Astronomy and Logic*, 189–210. Aldershot, Hampshire, England: Variorum, 1994.

Hall, M.B. “Arabick Learning in the Correspondence of the Royal Society 1660-1677.” In *The ‘Arabick” Interest of the Natural Philosophers in Seventeenth-Century England*, edited by G.A. Russell, 147–57. Leiden: E. J. Brill, 1994.

Henry, John. ‘Charleton, Walter (1620–1707)’ in *Oxford Dictionary of National Biography*. http://www.oxforddnb.com.ezproxy.lib.utexas.edu/view/article/5157 (accessed January 17, 2014).

Holt, P. M. *A Seventeenth-Century Defender of Islam: Henry Stubbe (1632-76) and His Book*. London: Dr. Williams’s Trust, 1972.

Ibn al-Haytham. *The Optics of Ibn Al-Haytham, Books I-III on Direct Vision*.

Translated by A.I. Sabra. 2 vols. London: The Warburg Institute, 1989.

MacLean, Gerald and Nabil Matar. *Britain and the Islamic World, 1558-1713*. Oxford: Oxford University Press, 2011.

Matar, Nabil. *Islam in Britain, 1558-1685*. Cambridge: Cambridge University Press, 2008.

Newman, William R. *Atoms and Alchemy: Chymistry and the Experimental Origins of the Scientific Revolution*. Chicago: University of Chicago Press, 2006.

Russell, G. A., ed. *The "Arabick" Interest of the Natural Philosophers in Seventeenth-Century England*. Leiden: E.J. Brill, 1994.

Sharp, Lindsay. "Walter Charleton's Early Life 1620-1659, and Relationship to Natural Philosophy in Mid-Seventeenth Century England." *Annals of Science* 30 (1973): 311-40.

Siraisi, Nancy G. *Avicenna in Renaissance Italy: The Canon and Medical Teaching in Italian Universities after 1500*. Princeton: Princeton University Press, 1987.

Smith, A. Mark. Introduction to *Alhacen's Theory of Visual Perception: A Critical Edition, with English Translation and Commentary, of the First Three Books of Alhacen's De Aspectibus, the Medieval Latin Version of Ibn Al-Haytham's Kitāb Al-Manāẓir*. Vol. 1. Philadelphia: American Philosophical Society, 2001.

Thomas, Keith. *Religion and the Decline of Magic: Studies in Popular Beliefs in Sixteenth and Seventeenth Century England*. New York: Scribner, 1971.

Toomer, Gerald J.. *Eastern Wisedome and Learning: The Study of Arabic in Seventeenth-Century England*. Oxford: Clarendon Press, 1996.

Tuck, Richard. "Optics and Sceptics: The Philosophical Foundations of Hobbes's Political Thought." In *Conscience and Casuistry in Early Modern Europe*, edited by Edmund Leites, 235-263. Cambridge: Cambridge University Press, 1988.

Wakefield, Colin. "Arabic Manuscripts in the Bodleian Library: The Seventeenth-Century Collections." In *The "Arabick" Interest of the Natural Philosophers in Seventeenth-Century England*, edited by G.A. Russell, 128–46. Leiden: E. J. Brill, 1994.

Watt, W. Montgomery. *The Influence of Islam on Medieval Europe*. Edinburgh: Edinburgh University Press, 1972.

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